Chapter 4

Tools and Equipment

Tools and equipment play a crucial role in optical fibre installation. Various tools and equipment used for the installation of optical fibre cable in the network are optical fibre stripper, scissors, cleaver, v-groove, screwdriver kit, crimping tool kit, etc. In this chapter, we will learn about the basic tools and instruments used in optical fibre installation.

Basic Hand Tools

Basic hand tools are those used in our day to day life whenever we are dealing with any repairing, drilling, cutting, etc. These tools are discussed below.

Screwdriver

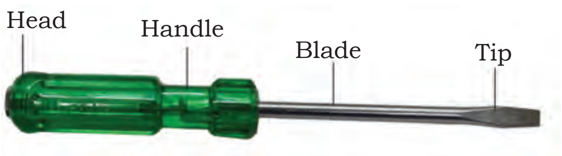

Fig. 4.1: Screwdriver and its parts

Screwdriver is a hand tool, specifically designed to insert and tighten the screws as well as to loosen and remove screws from the job. A screwdriver comprises a head or tip which is fixed to the screw head and force is applied to the screwdriver to tighten it in clockwise direction and to loosen it in anticlockwise direction. A typical simple screwdriver has a handle and a shaft as shown in Fig. 4.1.

The ending tip of the screwdriver is put into the screw head by the user before turning the handle as shown in Fig. 4.2.

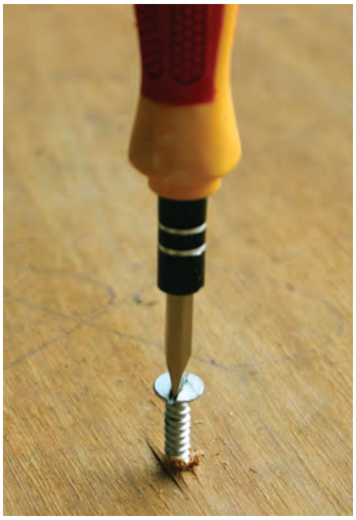

Fig. 4.2: Tip of the screwdriver is put into the screw head

The shaft is usually made of tough steel. It is used to resist bending or twisting. Handles are made up of wood, metal, or plastic. Handles are usually hexagonal, square, or oval in cross-section to improve grip. This will be helpful while twisting the screwdriver and will prevent the tool from rolling on the head of screw. Some screwdrivers have interchangeable tips that fit into a socket on the end of the shaft and are held in mechanically or magnetically. These often have a hollow handle that contains various types and sizes of tips as shown in Fig. 4.3.

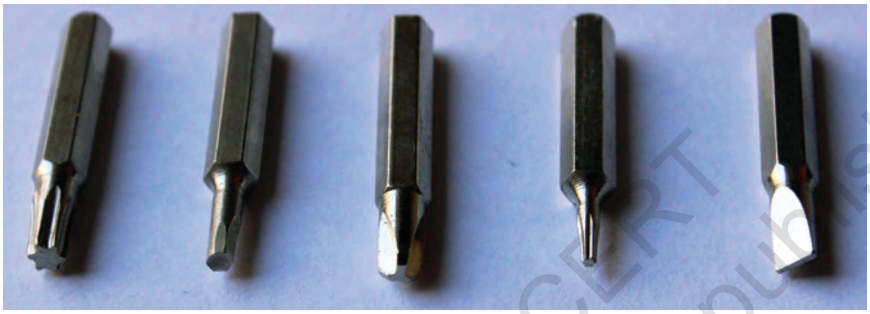

Fig. 4.3: Interchangeable tips of screwdrivers

Tips to use screwdrivers

The size of the screw and the type of opening it has determines which driver to use. Following are a few tips to use a driver.

1. Never use a driver to do another tool's job. It should be used for which it is designed.
2. Never push a driver beyond its capacity, never put excessive pressure on the screw head.
3. Never expose a driver to excessive heat, it will damage the shaft of the driver.
4. Never use a driver at an angle to the screw, it is always used in a perpendicular direction of screw head.
5. Never depend on a driver's handle or covered blade to insulate you from electricity.
6. Discard damaged or worn drivers.

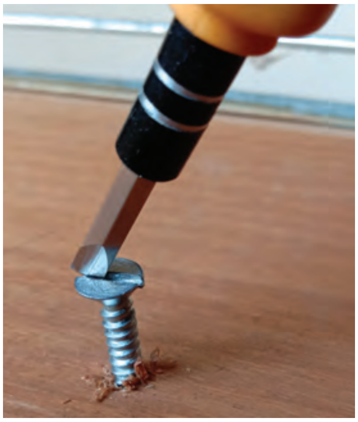

Fig. 4.4: Slip of tip of screwdriver

Slipping of tip of screwdriver

When driving certain types of screws, the screwdriver bit can slip out of the screw head, when a lot of torque (turning force) is applied (Fig. 4.4).

Stripping a screw head

A stripped screw head is the term used to describe a screw that has been damaged by a screwdriver bit (Fig. 4.5).

Stripped screws are the result of a number of things, Like,

- general wear and tear.
- using the wrong size or type of bit for the screw.
- the screwdriver slipping out of the screw's drive and damaging its surface.

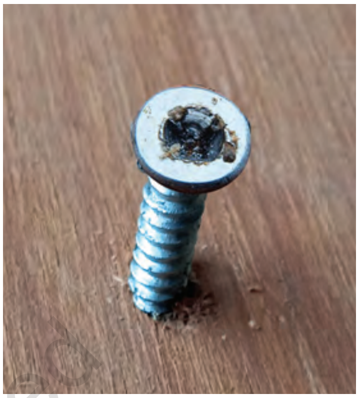

Fig. 4.5: Screwdriver damages the surface of screw

Fig. 4.6: Scissors

Scissors

Scissors are hand-operated tools. A pair of scissors consists of a pair of metal blades which are pivoted. The sharpened edges slide against each other when the handles (bows) opposite to the pivot are closed. Scissors are basically utilised for cutting purpose like paper, cardboard, metal foil, cloth, rope, and wire. A typical part of scissors is shown in Fig. 4.6. Fig. 4.7 shows the various parts of a scissor.

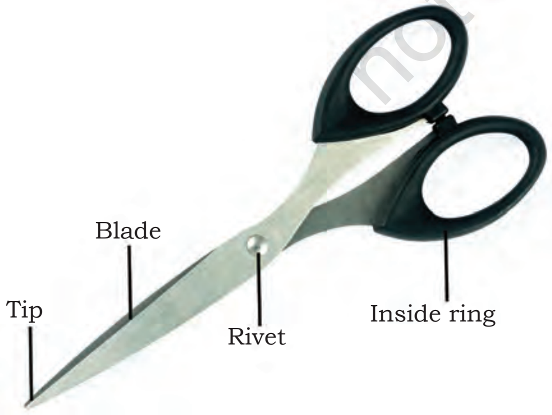

Fig. 4.7: Parts of Scissor

Precautions to be taken while handling the scissors are—

(a) Do not touch the blade of the scissors.

(b) Observe tip of scissors while cutting fibre threads.

Cable cutting knife

It has a sharp blade with comfortable, full-sized, handle. Its blade is made of the finest steel, tough and carefully tempered to hold its edge as shown in Fig. 4.8. The handle is textured for comfort and firm grip. A typical cable-cutting knife is shown in Fig. 4.8.

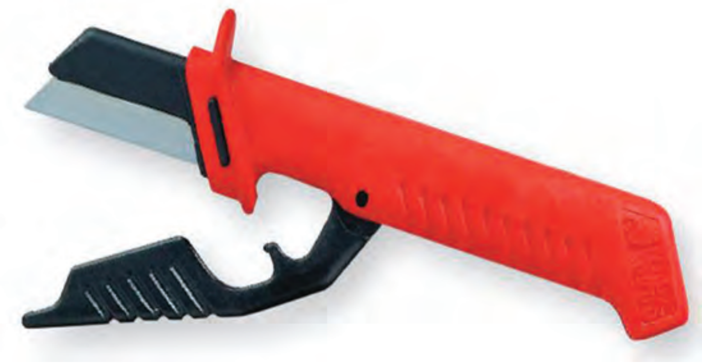

Fig. 4.8: Cable cutting knife

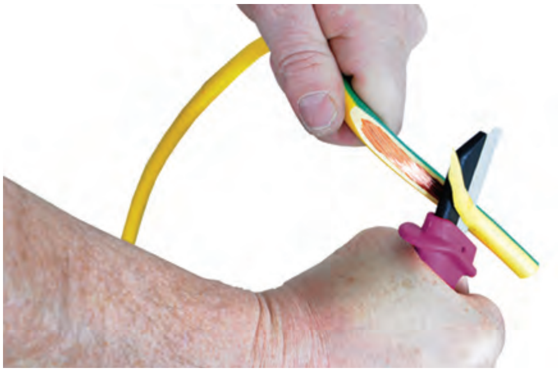

Fig. 4.9: Cable insulation stripping using cable cutting knife

Plier

Pliers are used for gripping or twisting of wires or cables. A typical plier is shown in Fig. 4.10. There are different parts of the plier like handles, jaws, cutter each with a specific operation. They are used to grip, splice or cut wires, and strip insulation.

Parts of pliers are as follows—

Handles

The handles of pliers have a plastic coating, for added comfort while holding it. It also provides good grip to the hands. The size and length of the handles will depend on the size of the pliers. Those designed for use by electricians and linemen have insulated handles.

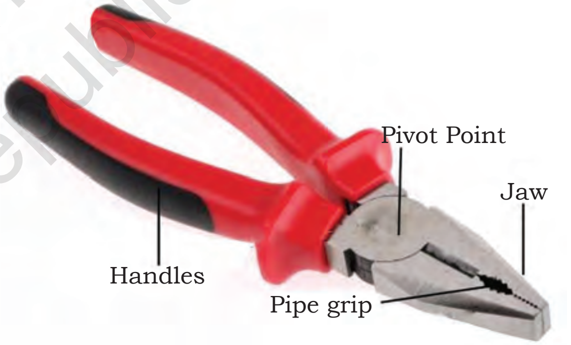

Fig. 4.10 Combination plier and its parts

Jaws

Handles are used to open and close the jaws of pliers. They have flat edges for general gripping, which are often serrated for extra grip, although sometimes they are smooth. They usually have squared tips.

Cutter

The cutters built into the jaws of combination pliers are usually designed to cut cables and wire.

Pipe grip

The pipe grip is a rounded, cut-out in the jaws. It is primarily used for gripping rounded stock, like pipes and cables.

Pivot point

The pivot point is a kind of hinge that allows the handles and tips to open and close so the jaws can grip or cut, and then be opened again.

Measuring tape

This is used for measurement of cable during splicing. A typical measuring tape is shown in Fig. 4.11.

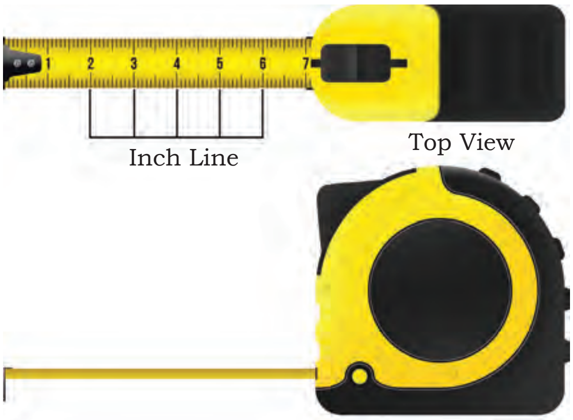

Fig. 4.11: Sub division of inch line on measuring tape

Tube cutter

This compact and light weight tool is used for removing the outer jacket and buffer coating from fibre. This tool has automatic return spring for ease of use and speed. Fig. 4.12 shows a typical tube cutter.

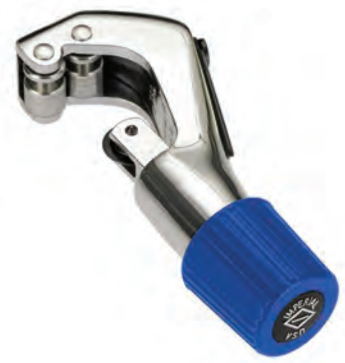

Fig. 4.12: Cable tube cutter

Operation of tube cutter

Place the optical fibre cable inside the jaws of the loose tube cutter. Inside the jaws there is a blade which is used to cut the optical fibre cable as shown in Fig. 4.13. Rotate the tube cutter around the fibre cable as shown in Fig. 4.14. Now gently pull the tube cutter to cut the fibres as shown in Fig. 4.15. The blade inside the jaws cuts the cable along the direction of the pulling (cuts the cable sheath). Pulling the cut outer jacket will reveal the inside fibre strands from it.

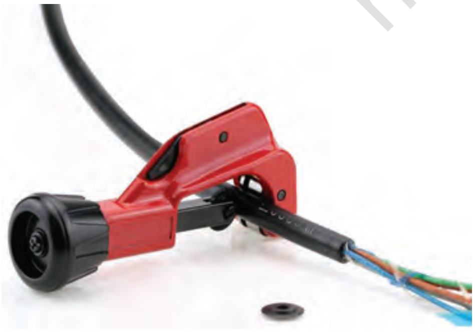

Fig. 4.13: Fibre cable inside tube cutter

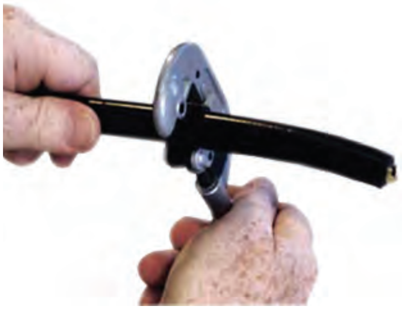

Fig. 4.14: Rotation of tube cutter around the cable

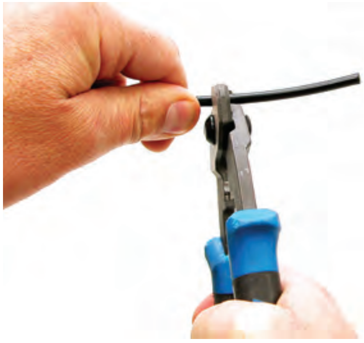

Fig. 4.15: Pulling out the jacket from cables

Optical fibre stripper

It is used for cutting and removing the primary coating of the optical fibres while splicing the optical fibre cable. A typical splicing tool is shown in Fig. 4.16. It enables the user to perform the combined operation of cutting and stripping. There are three slots or holes of cutting the fibre each with a different operation, i.e., stripping the fibre jacket (Fig. 4.19), fibre buffer, and fibre coating. Stripping activity of fibre optic cable is shown in Fig. 4.17 and the stripped cable after stripping is shown in Fig. 4.18.

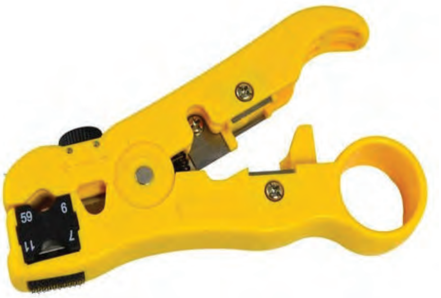

Fig. 4.16: Stripping tool

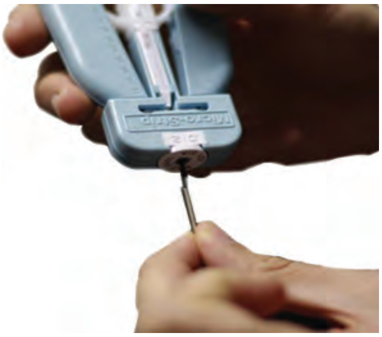

Fig. 4.17: Stripping of optical fibre cable

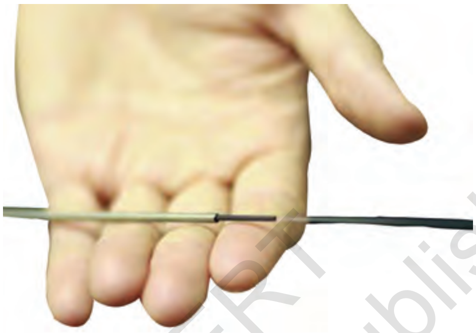

Fig. 4.18: Stripped optical fibre

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Practical Exercise

Activity

Steps to use optical fibre stripper.

Step 1: Use fibre optic stripper to strip fibre jacket as shown in Fig. 4.19.

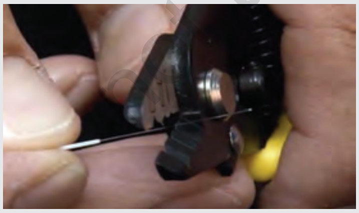


Fig. 4.19: Hold the fibre with the help of stripping tool

Step 2: Take down the stripped fibre jacket.

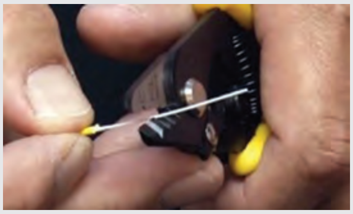


Fig. 4.20: Removal of the jacket of the optical fibre

Tools used for splicing

Splicing is a specialised technique of joining the broken ends of the optical fibre. The procedure of splicing requires special tools. Some of the important tools are discussed below.

Optical fibre splicing machine

A typical machine for fusion splicing fusion splicing is shown in Fig. 4.21. It is a small, lightweight machine with an LCD screen. This screen shows the splicing operation and internal view of the operations performed in machine during splicing. LCD screen shows the process of alignment in two directions, the fusion operation of the fibre. The optical joint machine calculates the power loss in the joint. It also has thermal heater to shrink the protection sleeve on the fibre.

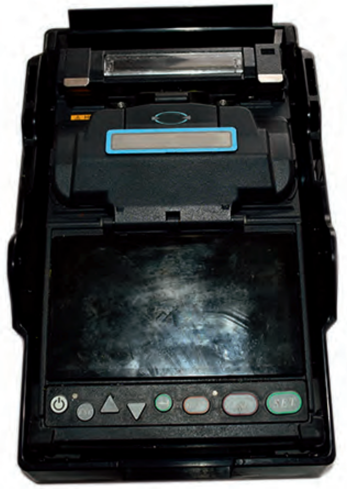


Fig. 4.21: Fusion splicing machine

Fibre optic cleaving tool

Fibre cleaving is used to cut the fibre ends perfectly perpendicular to the axis before joining. Cleaving is different from normal cutting of cable using steel blade/ knife. This method of cutting is applied specially for fibre since it is made up of glass. Glass cutting requires fine and polished ends for cutting and it can be done using the diamond cutter. It is a process of controlled breaking of glass of a bare fibre. When optical fibres are spliced, the fibre ends, i.e., core need to be prepared such that they have clean surfaces as shown in Fig. 4.22. Hence, the fibre to be cut is kept horizontally and the diamond blade is kept vertically. To get perfect splicing it is necessary to have cleaving. Hence, it is important that the surface is either perpendicular to the fibre axis or has a well-defined angle against the fibre axis.

Two types of cleaving tools are used for fibre cutting. They are—

- Scribe cleaver
- Precision cleaver

Scribe clever

These types of cleavers were used in earlier days. Fig. 4.22 shows the scribe cleaver. It is used to cleave the fibre manually. It is a traditional cleaving method, typically used to remove extra fibre from the end, using a simple hand tool called a scribe. Scribe cleavers are usually shaped like ballpoint pens with a diamond tipped blade. The scribe has a hard, sharp tip, generally made of carbide or diamond that is used to scratch the fibre manually. Then the operator pulls the fibre to break it. Since both the scribing and breaking processes are under manual control, this method varies greatly in repeatability. Most field and lab technicians don't use it for cleaving as they are not accurate. However, if in skilled hands, this scribe cleaver offers significantly less investment for repairs, installation, and training classes.

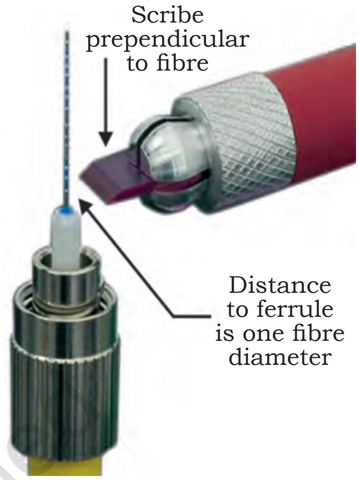

Scribe prependicular to fibre
Distance to ferrule is one fibre diameter

Fig. 4.22: Scribe cleaver

Precision cleaver

Precision cleavers are the most commonly used cleavers in the industry (Fig. 4.23). They use a diamond or tungsten wheel/blade to cut the fibre. Tension is then applied to the fibre to create the cleaved-end face. The advantage of these cleavers is that they can produce repeatable results through thousands of cleaves by simply just rotating the wheel/blade accordingly. Although more expensive than scribe cleavers, precision cleavers can cut multiple fibres while increasing speed, efficiency and accuracy. In the past, many cleavers were scribes, but over time with fusion splicers, good cleaving became the key to low splice loss.

Precautions to be taken

- Handle the scribe cleaver carefully.
- Don't place your finger at the diamond blade. It will cut your finger.
- Keep your mouth and nose away, at least at an arm's distance from alcohol.
- Label the bottle of alcohol and wash your hands with soap after using it.

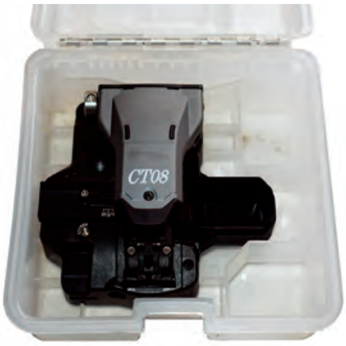


Fig. 4.23: Precision cleaver

Protection sleeves

Fibre optic protection sleeve is used during the process of optical fibre splicing as shown in Fig. 4.26. As we know, spliced bare fibres are fragile. Therefore, a good protection for the spliced fibres during fibre optic splicing

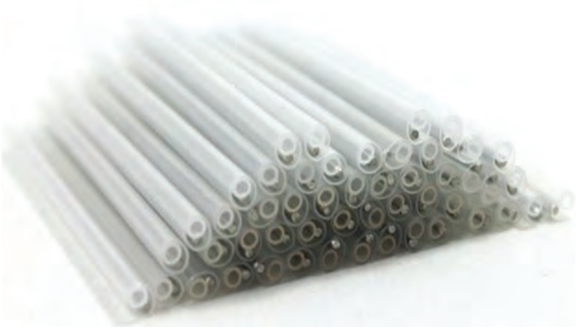


Fig. 4.24: Protection sleeves

is extremely necessary. Hence, a protection sleeve perfectly solves the issue. The sleeve acts like a strong coat for the fibre splices to prevent unpredictable fractures. Typical lengths of protection sleeves are 30 mm and 40 mm in diameter. The sleeve colour is selective, but most people would choose the transparent tube for better inspection of the fibre. Although the sleeve is very small, it provides great support for the fibre joint. Fibre optic splicing, especially fusion splicing, has become increasingly important. The process is done by joining the two ends to create longer cable runs.

Protection sleeves are made up of three parts:

1. Outer tube (heat shrinkable)
2. Inner tube (hot-melt glue)
3. Strength member

Outer tube (heat shrinkable)

It is made up of polyolefin based on polyethylene material. The outer high quality heat shrinkable tubing provides an instant shrink-force and drives the adhesive liner into all areas of the splice and excludes all the air.

Inner tube (hot-melt glue)

The hot-melt adhesive in the inner tube bonds to both the fibre and the heat shrinkable outer tube to encapsulate the fusion splice joint and provides vibration damping and an environmental seal, protecting the fibre from damage and contaminants.

Strength member

A choice of strength member (stainless steel, ceramic, or non-metallic) provides additional rigidity to prevent misalignment, micro bending or breaking of the Fibre.

Precautions to be taken while using protection sleeves

While utilising the fibre protection sleeves, the operator should take the following precautions to avoid unnecessary loss and secure the fibre for a long-term use.

1. Do not leave air bubbles in the protection tube. This ensures the long-term reliability of the fibre splices.
2. The tension applied to the fibre should be uniform so that the fibre can stay straight in the protective sleeve.
3. The tension applied to the fibre should not be too large in case fibre cracks increase.
4. Avoid fibre twisting because this may cause micro-bending and unnecessary fibre loss.
5. Do not release the tension until the heat-shrinkable tube is completely shrunk, cooled, and shaped. This can avoid the uneven heating which leads to fibre bending.

Tools for mechanical splicing

Basic tools used for the mechanical splicing are as below.

Mechanical splice connector

Fig. 4.25 and 4.26 show the basic mechanical splice connector and its structural description. Mechanical splicing creates temporary joints and can be disconnected. This type of splicing is less accurate than fusion splicing.

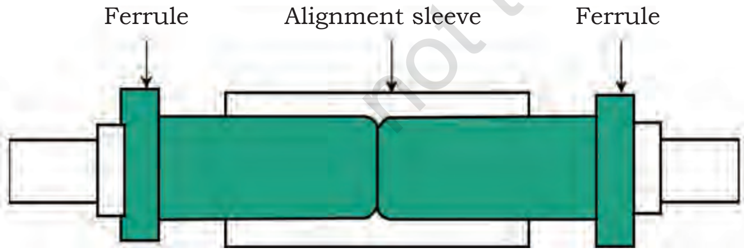


Fig. 4.25: Top view of mechanical connector

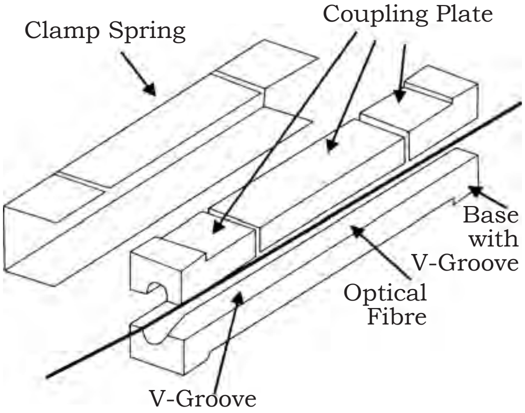


Fig. 4.26: Side view of mechanical connector

Ferrule

A ferrule is a component in optical fibre used for protecting and aligning the stripped fibre end. Material for a ferrule is selected keeping in mind a variety

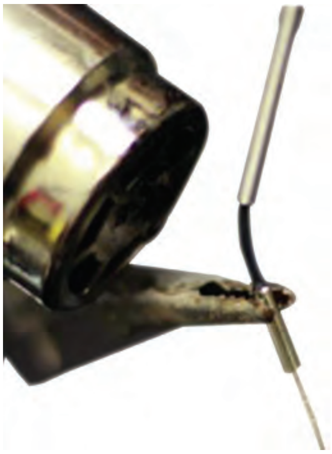


Fig. 4.27: Ferrule inserting into the optical fibre cable

of factors such as durability of the material, cost, connector mating frequency, surface finish over time and the material's ability to retain end-face geometry. Ferrules can be manufactured from plastic, glass, metal or from any ceramic material. Ceramic is considered the best material for ferrule. The end face of the ferrule should be precisely shaped, as this helps in having the optimum physical contact between each of the mated fibre pair as shown in Fig. 4.27.

V-groove

V-groove is the most commonly used alignment mechanism for mechanical fibre splices. Precision holes or V-groove is drilled or moulded through the centre of each ferrule allowed for fibre insertion and alignment. Precise fibre alignment depends on the accuracy of the central hole of each ferrule. The fibre alignment is done by using splicing machine having V-groove as shown in Fig. 4.29.

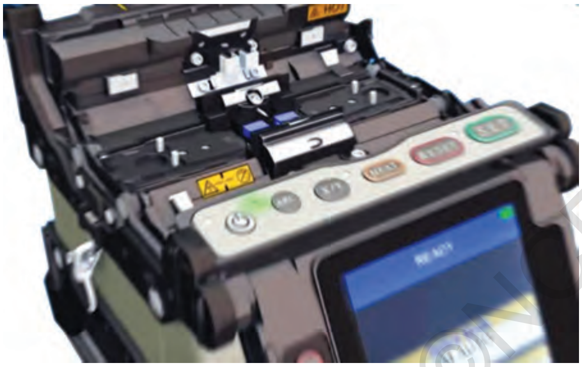


Fig. 4.28: Fibre splicing machine

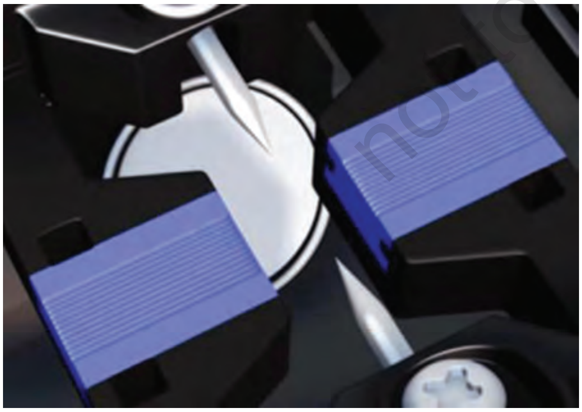


Fig. 4.29: Fibre splicing machine having V-groove

For this, the steps followed are —

- cleaved fibres are placed into the groove.
- index matching gel is used to bridge the gap between the two ends to prevent gap loss.
- a locking mechanism/clamp then holds the fibres in position and provides mechanical protection for the fibres.
- index matching epoxy can be used in place of index matching gel. The epoxy is usually cured with ultraviolet light. The epoxy can hold the fibres in place.

Matching gel

It is a gel which is used to match the refractive index of a material. The index-matching material is a substance, usually a liquid, cement (adhesive), or gel, which has an index of refraction that closely approximates that of fibre-optic. When two substances with the same index are in contact, light passes from one to the other with neither reflection nor refraction. The fibre is inserted into the thin structure of the ferrule and provided with an adhesive or matching gel to prevent contamination as well as to give it long-term mechanical strength. When the fibre ends are inserted, an adhesive, normally an epoxy resin, bonds the fibre inside the ferrule (Fig. 4.30).

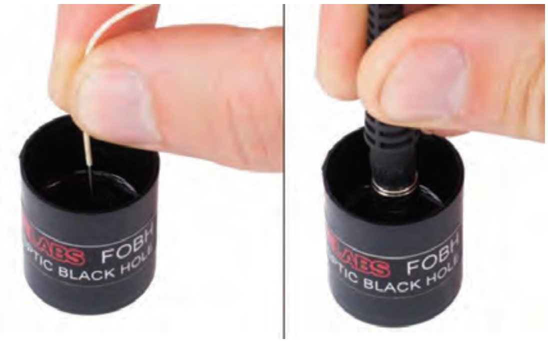


Fig. 4.30: Matching gel using for index matching

Clamp spring

After the fibre is properly aligned and joined/spliced by gel, the clamp is pressed above it protecting the jointed portion. It is used as a lock mechanism to hold the spliced fibre. A typical clamp spring is shown in Fig. 4.31.

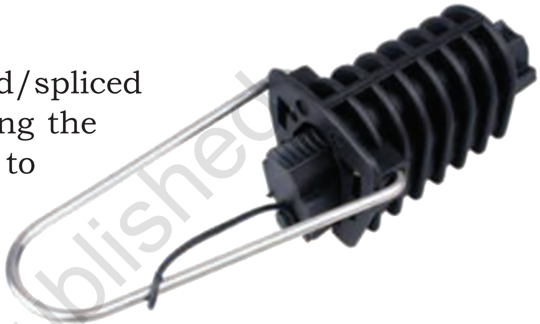


Fig. 4.31: Clamp spring

Cleaning tools and safety materials

Cleaning swab

Today's splicing equipment is fast, efficient and requires minimal maintenance due to advances in splicing technology. However, environmental contamination, such as dust, dirt and fibre coating debris, as well as, the silica deposits generated during the fusion process eventually find their way to the optical elements and V-grooves. This contamination offsets the fibre and degrades its performance. The cleaning swabs are high absorbency swabs and remove dust and other contaminants as shown in Fig. 4.32. They work well with solvent applicator like alcohol and offers outstanding particle entrapment. They have ideal size of 4.5 mm in length and their dimension is suitable for fusion splice mirror cleaning. They are available in durable, field-ready, transparent tubes.

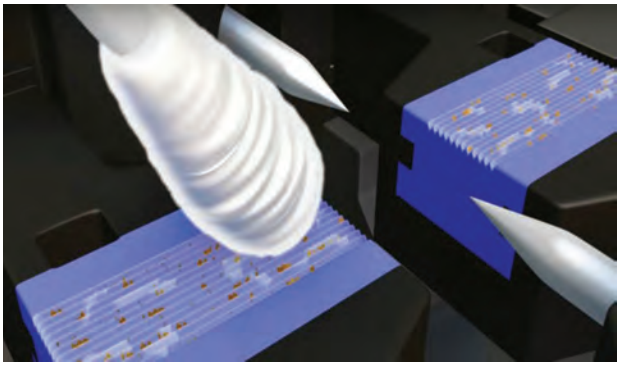


Fig. 4.32: Cleaning swab

Applications

- For fusion splice mirror cleaning
- Dust removal from precision surfaces

Fig. 4.33: Tissue paper

Tissue paper

It is a lightweight paper used for cleaning the fibre after stripping it. It is made by recycling paper pulp. It comes in bundle or packet and white in colour as shown in Fig. 4.33. It is very cheap and is used to clean the jelly which is above the core and cladding. Dry tissue paper is taken with few drops of isopropyl alcohol above it and then it is used to clean the fibre.

Note

- Don't touch the tissue paper with dirty or wet hands.
- Used tissue paper should be disposed off in bin and cannot be reused.

Alcohol

This fast-acting cleaner can be used with dry fibre wipes or tissues to remove jelly above the fibre core, or dust from optical fibre prior to termination and fibre optic splicing or to clean the end of the fibre. A fast evaporating alcohol based chemical named as isopropyl is used with the tissue paper to clean the bare fibre as shown in Fig. 4.34.

Fig. 4.34: Isopropyl alcohol

Gloves

Gloves are used for safety during splicing as shown in Fig. 4.35.

Fig. 4.35: Hand gloves

Check Your Progress

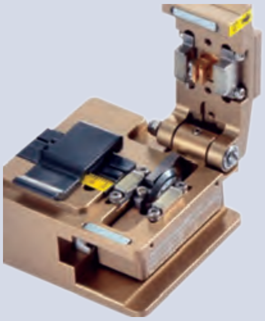
Notes

A. Multiple Choice Questions

1. Which of the following is not a part of screw driver?
   - (a) Head
   - (b) Shaft
   - (c) Tip
   - (d) V groove
2. Which of the following is not a type of screw driver tip?
   - (a) Cabinet
   - (b) Keystone
   - (c) Square
   - (d) Triangle
3. Which of the following is not a part of scissors?
   - (a) Tip
   - (b) Blade
   - (c) Inside ring
   - (d) Handle
4. Which of the following is not a part of plier?
   - (a) Jaws
   - (b) Pivot point
   - (c) Cutter
   - (d) All of the above
5. Which of the following cutting tool is rotated around the optical fibre several times to create a cut in the buffer tube?
   - (a) Plier
   - (b) Nose plier
   - (c) Tube cutter
   - (d) Cleaver
6. Which of the following tool enables the user to perform the combined operation, i.e., cutting and stripping?
   - (a) Optical fibre stripper
   - (b) Nose plier
   - (c) Cleaver
   - (d) Scissor
7. Which of the following is the most commonly used alignment mechanism for mechanical fibre splices?
   - (a) Cleaning swab
   - (b) V-groove
   - (c) Matching gel
   - (d) Clamp spring

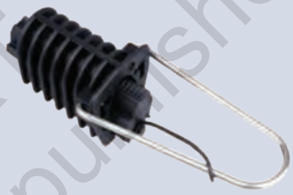
NOTES

8. Identify the following picture and choose the appropriate name for the equipment from the given options.



   (a) Scriber cleaver
   (b) Precise cleaver
   (c) Optical power meter
   (d) Optical Time Domain Reflectometer

9. Identify the following picture and choose the appropriate name for the equipment from the given options.



   (a) Clamp spring
   (b) Mechanical spring
   (c) Optical spring
   (d) Precise cleaver

B. Fill in the Blanks

1. In order to tighten the screw, the force applied to the screwdriver is in ________________ direction.
2. In order to loosen the screw, the force applied to the screwdriver is in ________________ direction.
3. Cable can be placed in a figure of ________________ which prevents the twisting of fibre cables.
4. Ferrules are typically made of ___________, _____________ or quality plastic.
5. Tube cutter is ________________, ________________, and more convenient way of cutting cable.
6. Before installation of the cable, check the _____________ and ________________ of the cable.
7. For temporary joint of optical fibre cable ________________ is used.
8. For cleaving the optical fibre _______________ material is used.

9. Typical lengths of protection sleeves are _______________ and __________________ in diameter.
10. Coupling device is a part of the connector body that keeps the _____________ in place when attached to another device.

C. Answer in Brief

1. Define the following terms
   - (a) Precise cleaving
   - (b) Cable pulling
   - (c) Cable placement
   - (d) Matching gel
   - (e) Cleaning swab
2. What is the significance of using matching gel and how is it used?
3. Name the tools used for fibre splicing.
4. Write down the safety and care measures taken to handle various tools and equipment.
5. Write down the tips to use a screwdriver.